Classifications of routing protocols

The routing protocols for ad hoc wireless networks can be broadly classified into four categories based on

- Routing information update mechanism
- Use of temporal information for routing
- Routing topology
- Utilization of specific resources

Classifications of Routing Protocol:

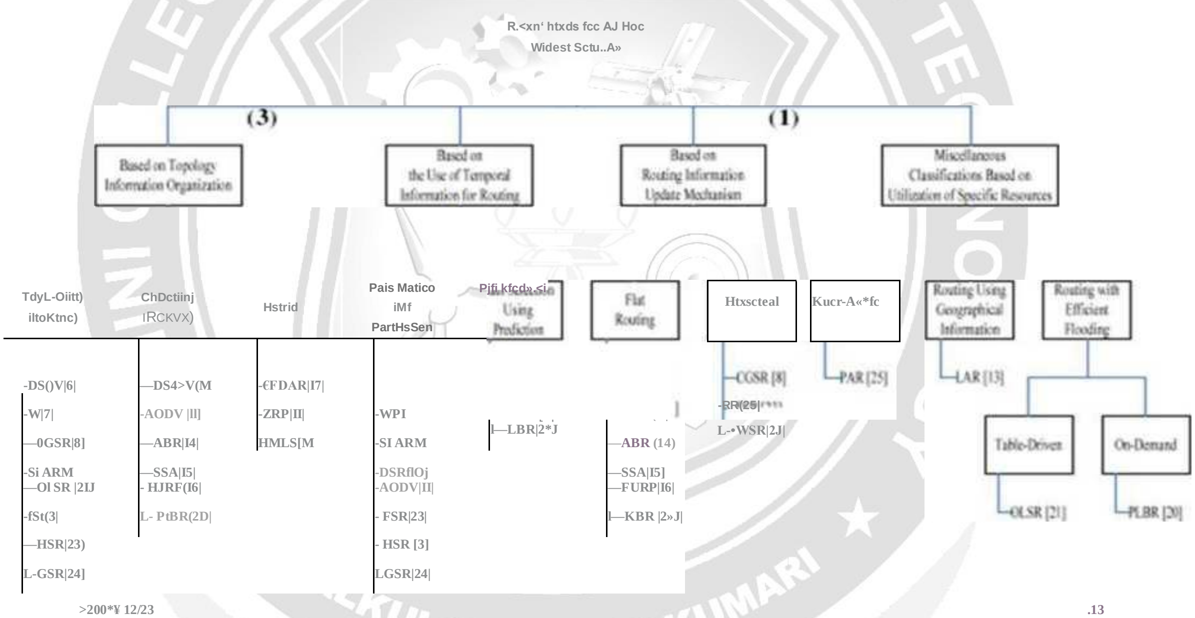


Figure 7.4. Clusifcitiom of routing pvtecok

Based on the Routing Information Update Mechanism

Ad hoc wireless network routing protocols can be classified into three major categories based on the routing information update mechanism. They are:

1. **Proactive or table-driven routing protocols:** In table-driven routing protocols, every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network. Whenever a node requires a path to a destination, it runs an appropriate path-finding algorithm on the topology information it maintains.
2. **Reactive or on-demand routing protocols:** Protocols that fall under this category do not maintain the network topology information. They obtain the necessary path when it is required, by using a connection establishment process. Hence these protocols do not exchange routing information periodically.
3. **Hybrid routing protocols:** Protocols belonging to this category combine the best

features of the above two categories. Nodes within a certain distance from the node concerned, or within a particular geographical region, are said to be within the routing zone of the given node. For routing within this zone, a table-driven approach is used. For nodes that are located beyond this zone, an on-demand approach is used.

Based on the Routing Topology

Routing topology being used in the Internet is hierarchical in order to reduce the state information maintained at the core routers. Ad hoc wireless networks, due to their relatively smaller number of nodes, can make use of either a flat topology or a hierarchical topology for routing.

1. **Flat topology routing protocols:** Protocols that fall under this category make use of a flat addressing scheme similar to the one used in IEEE 802.3 LANs. It assumes the presence of a globally unique (or at least unique to the connected part of the network) addressing mechanism for nodes in an ad hoc wireless network.
2. **Hierarchical topology routing protocols:** Protocols belonging to this category make use of a logical hierarchy in the network and an associated addressing scheme. The hierarchy could be based on geographical information or it could be based on hop distance.

Based on the Utilization of Specific Resources

1. **Power-aware routing:** This category of routing protocols aims at minimizing the consumption of a very important resource in the ad hoc wireless networks: the battery power. The routing decisions are based on minimizing the power consumption either locally or globally in the network.
2. **Geographical information assisted routing:** Protocols belonging to this category improve the performance of routing and reduce the control overhead by effectively utilizing the geographical information available.

TABLE-DRIVEN ROUTING PROTOCOLS

Destination sequenced distance-vector routing protocol

- It is an enhanced version of the distributed Bellman-Ford algorithm where each node maintains a table that contains the shortest distance and the first node on the shortest path to every other node in the network.
- It incorporates table updates with increasing sequence number tags to prevent loops, to counter the count-to-infinity problem, and for faster convergence.
- As it is a table-driven routing protocol, routes to all destinations are readily available at every node at all times.
- The tables are exchanged between neighbors at regular intervals to keep an up-to-date view of the network topology.

- The table updates are of two types:
- ***Incremental updates:*** Takes a single network data packet unit (NDPU). These are used when a node does not observe significant changes in the local topology.
- ***Full dumps:*** Takes multiple NDPUs. It is done either when the local topology changes significantly or when an incremental update requires more than a single NDPU.
- Table updates are initiated by a destination with a new sequence number which is always greater than the previous one.

- Consider the example as shown in figure one. Here node 1 is the source node and node 15 is the destination. As all the nodes maintain global topology information, the route is already available as shown in figure two.
- Here the routing table node 1 indicates that the shortest route to the destination node is available through node 5 and the distance to it is 4 hops, as depicted in figure two.
- The reconfiguration of a path used by an on-going data transfer session is handled by the protocol in the following way.
- The end node of the broken link initiates a table update message with the broken link's weight assigned to infinity (w) and with a sequence number greater than the stored sequence number for that destination.
- Each node upon receiving an update with weight w, quickly disseminates it to its neighbors in order to propagate the broken-link information to the whole network.
- A node always assign an odd number to the link break update to differentiate it from the even sequence number generated by the destination.
- Figure shows the case when node 11 moves from its current position.

Advantages

- Less delay involved in the route setup process.
- Mechanism of incremental update with sequence number tags makes the existing wired network protocols adaptable to ad hoc wireless networks.
- The updates are propagated throughout the network in order to maintain an up-to-date view of the network topology at all nodes.

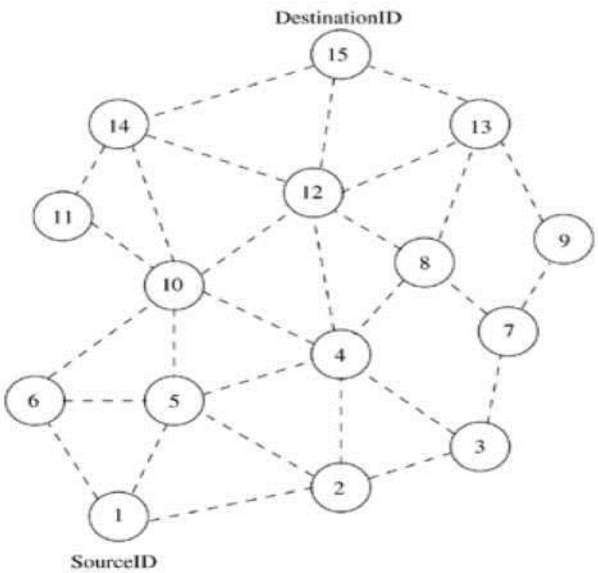
Disadvantages

- The updates due to broken links lead to a heavy control overhead during high mobility.
- Even a small network with high mobility or a large network with low mobility can completely choke the available bandwidth.
- Suffers from excessive control overhead.
- In order to obtain information about a particular destination node, a node has

to wait for a table update message initiated by the same destination node.

- This delay could result in state routing information at nodes.

Route establishment in DSDV

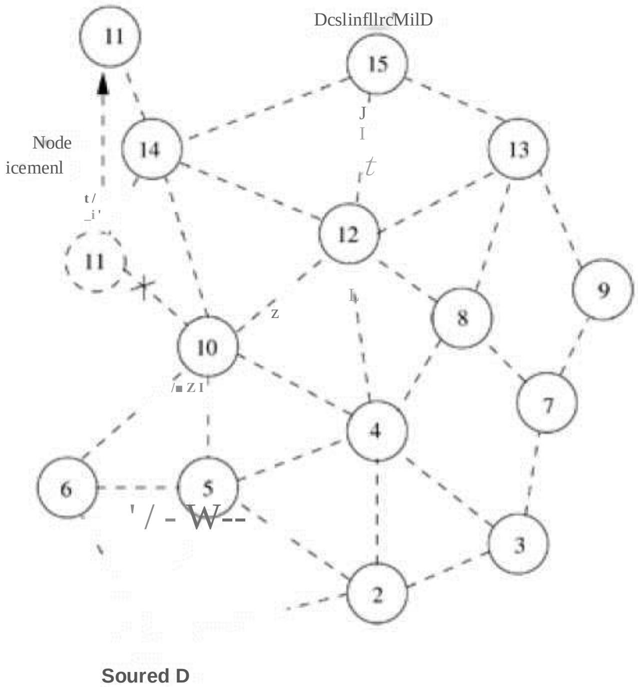


(a) Topology graph of the network

Dest	NextNode	Dist	SeqNo
2	2	1	22
3	2	2	26
4	5	2	32
5	5	1	134
6	6	1	144
7	2	3	162
8	5	3	170
9	2	4	186
10	6	2	142
11	6	3	176
12	5	3	190
13	5	4	198
14	6	3	214
15	5	4	256

(b) Routing table for Node 1

Route maintenance in DSDV



Routing Table for Node I

Desl	NexlNuds	Di st	SeqNu
2	2		22
3	2	2	26
4	5		32
5	5	1	134
6	fi	1	144
7	2	3	162
s	5	3	170
9	2	4	186
10	6	2	142
11	5	4	ISO
12	5	3	190
13	5	4	198
14	fi	3	214
15	5	4	256

ON-DEMAND ROUTING PROTOCOLS

They execute the path-finding process and exchange routing information only when a path is required by a node to communicate with a destination

Dynamic Source Routing Protocol (DSR)

- Designed to restrict the bandwidth consumed by control packets in adhoc wireless networks by eliminating the periodic table update messages
- It is beacon-less and does not require periodic hello packet transmissions
- Basic approach to establish a route by flooding RouteRequest packets in the network
- Destination node responds by sending a RouteReply packet back to the source
- Each RouteRequest carries a sequence number generated by the source node and the path it has traversed
- A node checks the sequence number on the packet before forwarding it
- The packet is forwarded only if it is not a duplicate RouteRequest
- The sequence number on the packet is used to prevent loop formations and to avoid multiple transmissions
- Thus, all nodes except the destination forward a RouteRequest packet during the route construction phase
- In figure one, source node 1 initiates a RouteRequest packet to obtain a path for destination node 15
- This protocol uses a route cache that stores all possible information extracted from the source route contained in a data packet
- During network partitions, the affected nodes initiate RouteRequest packets
- DSR also allows piggy-backing of a data packet on the RouteRequest
- As a part of optimizations, if the intermediate nodes are also allowed to originate RouteReply packets, then a source node may receive multiple replies from intermediate nodes
- In figure two, if the intermediate node 10 has a route to the destination via node 14, it also sends the RouteReply to the source node
- The source node selects the latest and best route and uses that for sending data packets

- Each data packet carries the complete path to its destination
- If a link breaks, source node again initiates the route discovery process

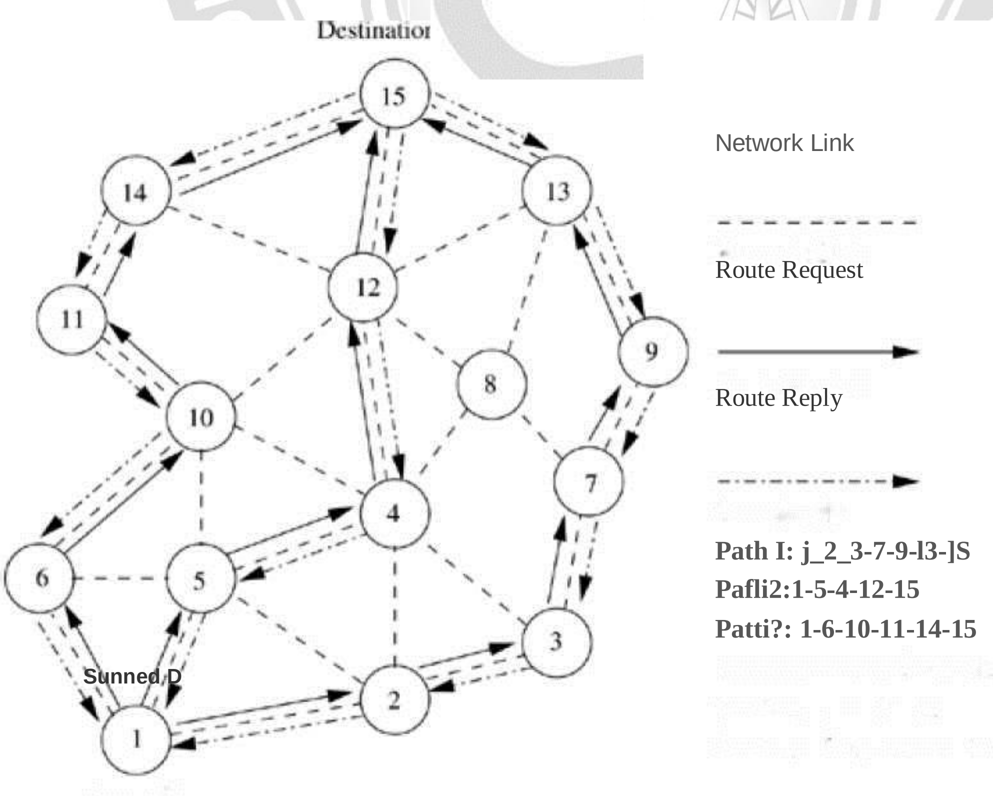
Advantages

- Uses a reactive approach which eliminates the need to periodically flood the network with table update messages
- Route is established only when required
- Reduce control overhead

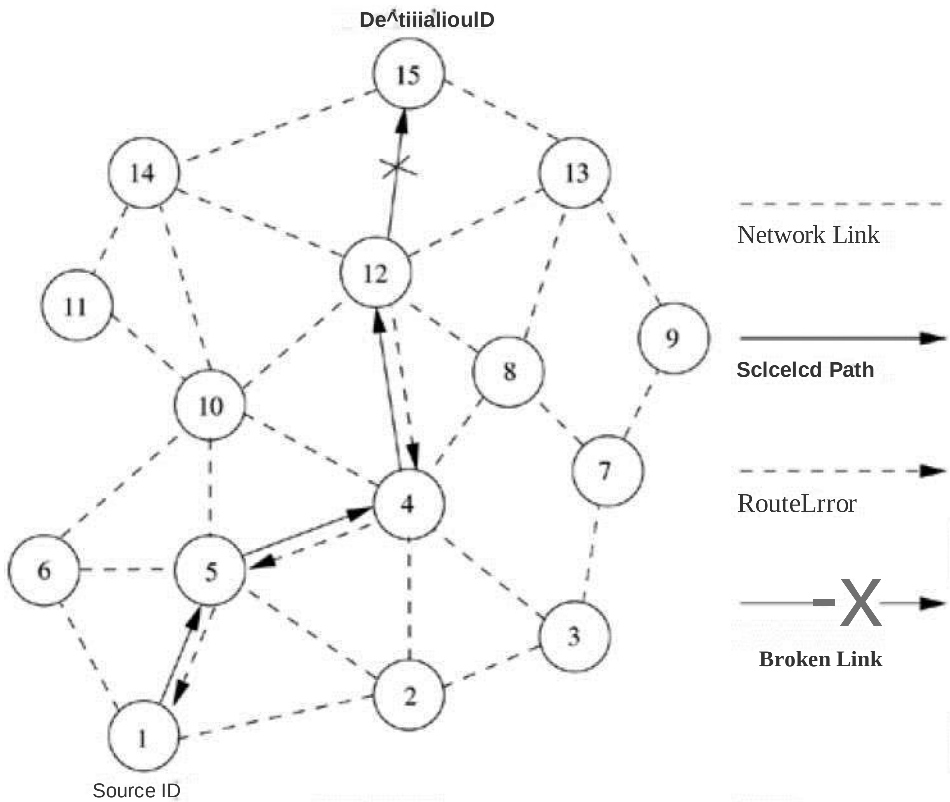
Disadvantages

- Route maintenance mechanism does not locally repair a broken link
- Stale route cache information could result in inconsistencies during route construction phase
- Connection set up delay is higher
- Performance degrades rapidly with increasing mobility
- Routing overhead is more & directly proportional to path length

Route establishment in DSR



Route maintenance in DSR



Ad Hoc On-Demand Distance Vector Routing Protocol

- Route is established only when it is required by a source node for transmitting data packets
- It employs destination sequence numbers to identify the most recent path
- Source node and intermediate nodes store the next hop information corresponding to each flow for data packet transmission
- Uses DestSeqNum to determine an up-to-date path to the destination
- A RouteRequest carries the source identifier, the destination identifier, the source sequence number, the destination sequence number, the broadcast identifier and the time to live field
- DestSeqNum indicates the freshness of the route that is accepted by the source
- When an intermediate node receives a RouteRequest, it either forwards it or prepares a RouteReply if it has a valid route to the destination
- The validity of the intermediate node is determined by comparing the sequence numbers
- If a RouteRequest is received multiple times, then duplicate copies are discarded
- Every intermediate node enters the previous node address and its BcastID
- A timer is used to delete this entry in case a RouteReply packet is not received
- AODV does not repair a broken path locally
- When a link breaks, the end nodes are notified
- Source node re-establishes the route to the destination if required

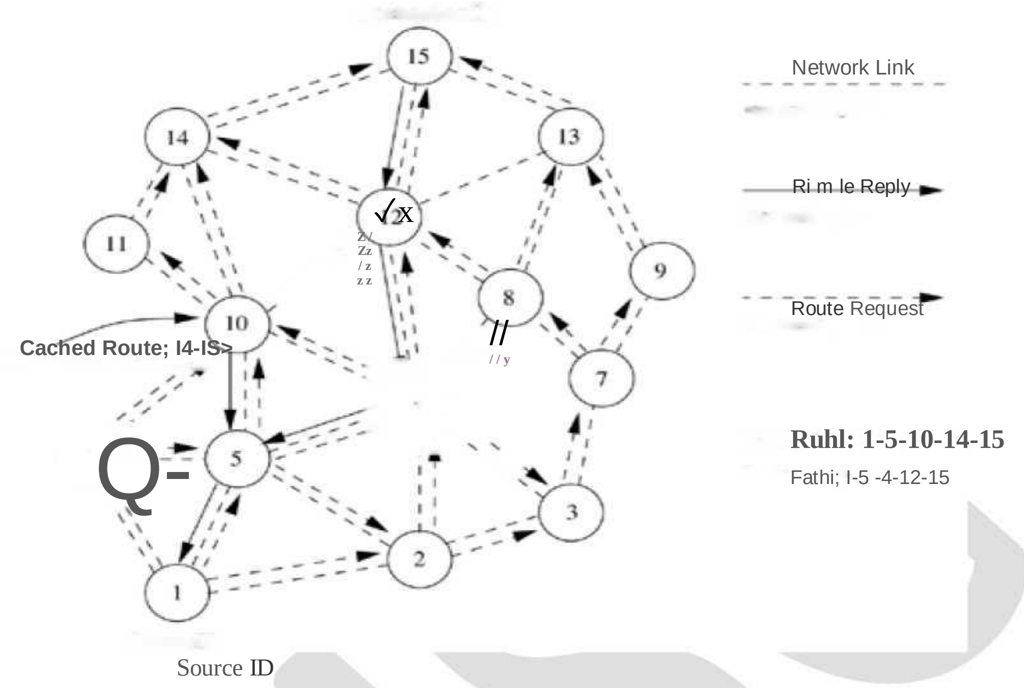
Advantage

- Routes are established on demand and DestSeqNum are used to find latest route to the destination
- Connection setup delay is less

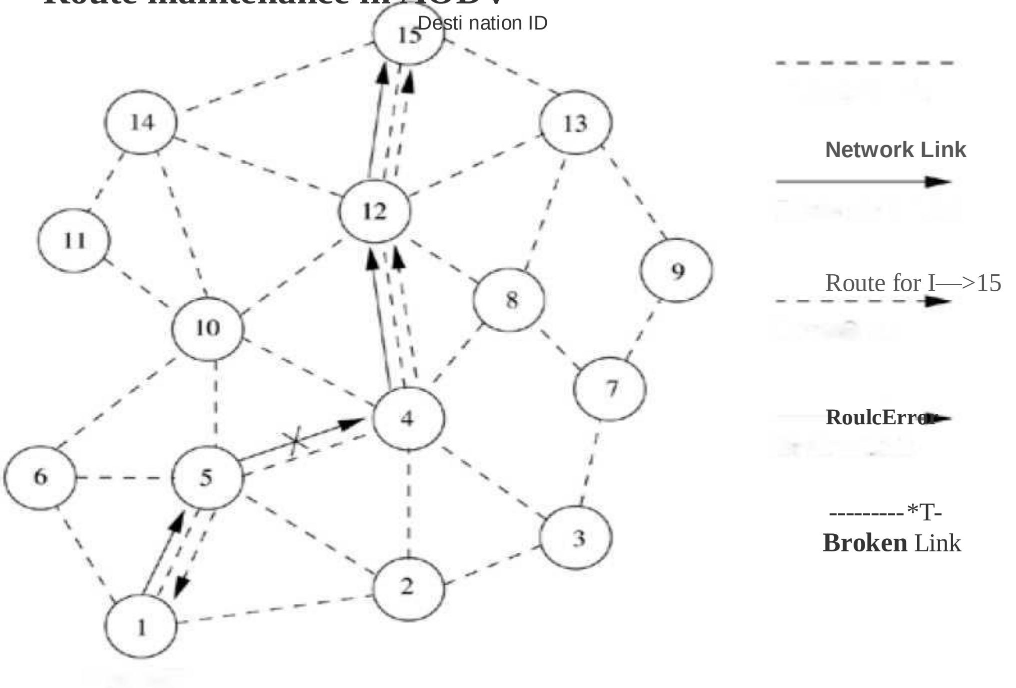
Disadvantages

- Intermediate nodes can lead to inconsistent routes if the source sequence number is very old
- Multiple RouteReply packets to single RouteRequest packet can lead to heavy control overhead
- Periodic beaconing leads to unnecessary bandwidth consumption

Route establishment in AODV



Route maintenance in AODV



SourceID